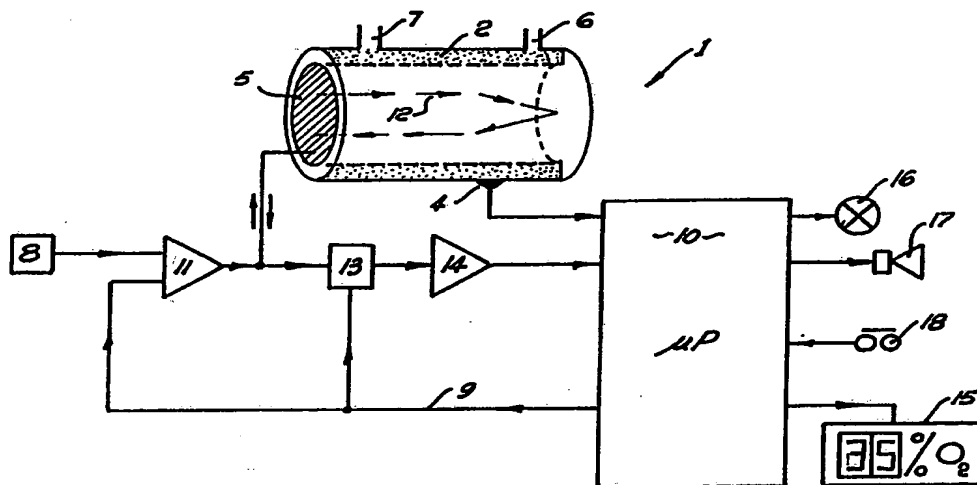


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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: GAS ANALYSER**(57) Abstract**

A gas analyser (1) for determining the respective proportions of the components of a mixture of two gases, includes a chamber (2) having an inlet (6) and an outlet (7) allowing the gas mixture to flow through the chamber. The analyser also includes transmitter means (5) and receiver means (5) for respectively transmitting and receiving ultrasonic pulses (12) and means to provide a measure of the proportions of the gaseous components from the transit time of a pulse transmitted by the transmitter means and received by the receiver means.

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Title: GAS ANALYSER

Technical Field

The present invention relates to gas analysers for determining the composition of gas mixtures and, in particular, to a device for use in monitoring mixtures of two gaseous components for an undesirable level of one component. As used herein the term gaseous component is intended to embrace a single gas or a gas mixture of known composition.

The invention finds particular application in the field of medicine for use in monitoring analgesic gas mixtures for low levels of oxygen. Although the invention has application to other fields of use, it will be described herein with reference to this application, that is as a low oxygen monitor. Typically in these instances the two gases are oxygen and nitrous oxide.

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Background Art

Previous methods of determining oxygen concentration have relied on chemical cells. These devices have the disadvantage of finite life due to cell consumption and, furthermore, have to be constantly recalibrated against inherent drift. Another method of determining the concentration of oxygen is the so-called paramagnetic analyser. Unlike chemical cells, this is a non-consumable device. It is, however, very expensive because of the required precision of its mechanical components.

Disclosure of the Invention

It is an object of the present invention to overcome or at least ameliorate the disadvantages of the prior art.

Accordingly, there is provided a gas analyser for determining respective proportions of two gaseous components in a mixture, said analyser including a chamber having an inlet and an outlet for said mixture positioned to provide a flow of said mixture through said chamber, transmitter means to transmit an ultrasonic pulse, receiver means to receive said pulse, and means to provide a measure of the proportions of said gaseous components from the transit time of a pulse transmitted by said transmitter and received by said receiver means.

Preferably, both the transmitter means and the

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receiver means are provided by a single ultrasonic transducer positioned at one of the ends of said chamber and the pulse received by the receiver means is an echo of the pulse transmitted by the transmitter means.

Preferably also, the chamber is cylindrical. The means to provide a measure of the composition of the mixture also preferably includes means to compare the composition with predetermined limits for producing alarm signals in the event that the composition falls outside those limits.

The invention allows the speed of sound in a mixture of two known gaseous components to be determined. From the knowledge of the velocity of sound in each of the constituent gas components can be determined the proportion of each in a mixture when the velocity of sound in the mixture is measured. When one or both component gases is itself a mixture, the composition in terms of those component gases can still be determined if the composition of each is known and constant.

It is known that the velocity of sound u , in a gas is proportional to the absolute temperature of the gas, T , and its molecular weight, M , in the following relationship:

$$u \propto (T/M)^{0.5}$$

The following table illustrates typical values of sound velocities at a constant temperature of 293°K:

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<u>GAS</u>	<u>VELOCITY OF SOUND</u>	<u>(MEAN) MOLECULAR WEIGHT</u>
AIR	344 m/s	28.8
OXYGEN	326 m/s	32.0
NITROUS OXIDE	278 m/s	44.01

At a constant temperature the velocity of sound in a gas mixture is a function only of the mean molecular weight of the mixture.

Naturally, in practice a method of temperature compensation is required to allow the system to operate accurately over a range of ambient temperatures.

Brief Description of the Drawings

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a block diagram of a gas analyser according to the invention; and

Figure 2 is a schematic diagram showing the gas analyser of Figure 1 incorporated in an anaesthetic machine.

Best Mode for Carrying Out the Invention

Referring now to Figure 1, the gas analyser 1 includes an elongate cylindrical chamber 2. An ultrasonic transducer 5 is located at one of the ends and the chamber includes an inlet 6 and an outlet 7 for gas mixtures. The inlet and outlet are located at

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opposite ends of the chamber to ensure that the composition of gas in the entire chamber reflects the composition of the gas flowing into the inlet. The gas analyser is therefore able to monitor the composition of time varying gas mixtures. In addition a temperature sensor 4 provides a measure of temperature of the gas in the chamber.

An oscillator 8 of conventional design generates a 49 kHz signal which is gated by a 1.5 millisecond pulse 9 initiated from a microprocessor 10. The resulting 49 kHz burst is amplified 11 and fed to the transducer. A pulse of sound 12 travels along the chamber through the gas mixture and echoes from the far end, returning to the transducer. The corresponding electrical signal is gated 13 to distinguish it from the original pulse and detected by a receiver 14 which feeds the signal back to the microprocessor.

The microprocessor registers the delay between the original pulse and the echo and therefore, given the dimensions of the chamber, can calculate the speed of sound in the gas mixture and therefore its mean molecular weight. Any compensation for the effects of changes in temperature may be applied at this time by virtue of the measurement from the temperature sensor 4.

The dimensions of the chamber are constrained by the duration of the ultrasonic pulse and the speed of sound. A chamber 300 mm long and 40 mm in diameter

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allows the leading edge of the transmitted pulse to return to the transducer in approximately 2 ms. This permits the echo pulse to be distinguished from the original pulse. The percentage of either or both constituents may therefore be calculated and displayed, for example, on a digital readout 15. Alternatively, the transit time may be compared with predetermined values and a visual 16 or audible 17 alarm initiated when the transit time falls outside those values. Where an audible alarm is provided a method of silencing the alarm is desirable. Accordingly, a mute switch 18 is provided. Further features of the preferred embodiment, not shown in Figure 1, include a power supply with rechargeable battery and automatic battery management circuitry. In accordance with relevant standards, the gas analyser provides an indication that the battery is adequately charged for standby use.

Industrial Applicability

Figure 2 illustrates the application of the gas analyser as a low oxygen monitor in an anaesthetic machine. In such a machine, regulated oxygen 19, nitrous oxide 20 and air 21 are variously mixed for supply to the fresh gas outlet 22. The machine allows combination of either air or nitrous oxide with oxygen and further allows the vapour of an anaesthetic agent to be added to the gas mixture by means of a vapouriser 23. The pressure of the oxygen supply is used to

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control the supply of the nitrous oxide through valve 24. If no oxygen is available, no nitrous oxide flows. The machine can be switched off by interrupting the oxygen supply at 26 in which case interruption of the air supply can be effected by valve 25.

The anaesthetic machine is augmented by addition of the gas analyser of the invention 27. The cylindrical chamber 28 is connected in line with the gas mixture, before the vapouriser, and the transducer is wired to the gas analyser. Pressure switches 29, 30 and 31 monitor oxygen, nitrous oxide and air pressure respectively and a solenoid/whistle 32 is connected to the oxygen supply so that the gas analyser can initiate an audible signal in the event of error conditions. A safety valve 33 prevents overpressure in the gas mixture and it should be noted that, as an additional safety feature, the gas analyser does not control the operation of the anaesthetic machine and can in fact be added to existing machines with a minimum of wiring and plumbing.

Although the invention has been described with reference to specific embodiments, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A gas analyser for determining respective proportions of two gaseous components in a mixture, characterised by the inclusion of a chamber having an inlet and an outlet for said mixture positioned to provide a flow of said mixture through said chamber, transmitter means to transmit an ultrasonic pulse, receiver means to receive said pulse, and means to provide a measure of the respective proportions of said gaseous components from the transit time of a pulse transmitted by said transmitter means and received by said receiver means.
2. A gas analyser as claimed in Claim 1, wherein the chamber is elongate and both transmitter means and receiver means are provided by a single ultrasonic transducer positioned at one of the ends of said chamber, said pulse received by said receiver means being an echo of the pulse transmitted by the transmitter means.
3. A gas analyser as claimed in Claim 1 or Claim 2, wherein the chamber is cylindrical.
4. A gas analyser as claimed in any one of the preceding claims, further comprising means to compare the determined proportions with predetermined limits for producing alarm signals in the event that the proportions fall outside those limits.
5. A gas analyser as claimed in any one of the

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preceding claims, wherein the longitudinal dimension of the chamber is such that the transit time of the pulse is greater than the duration of the pulse.

6. A gas analyser as claimed in any one of the preceding claims, wherein the duration of the pulse is 1.5 ms.

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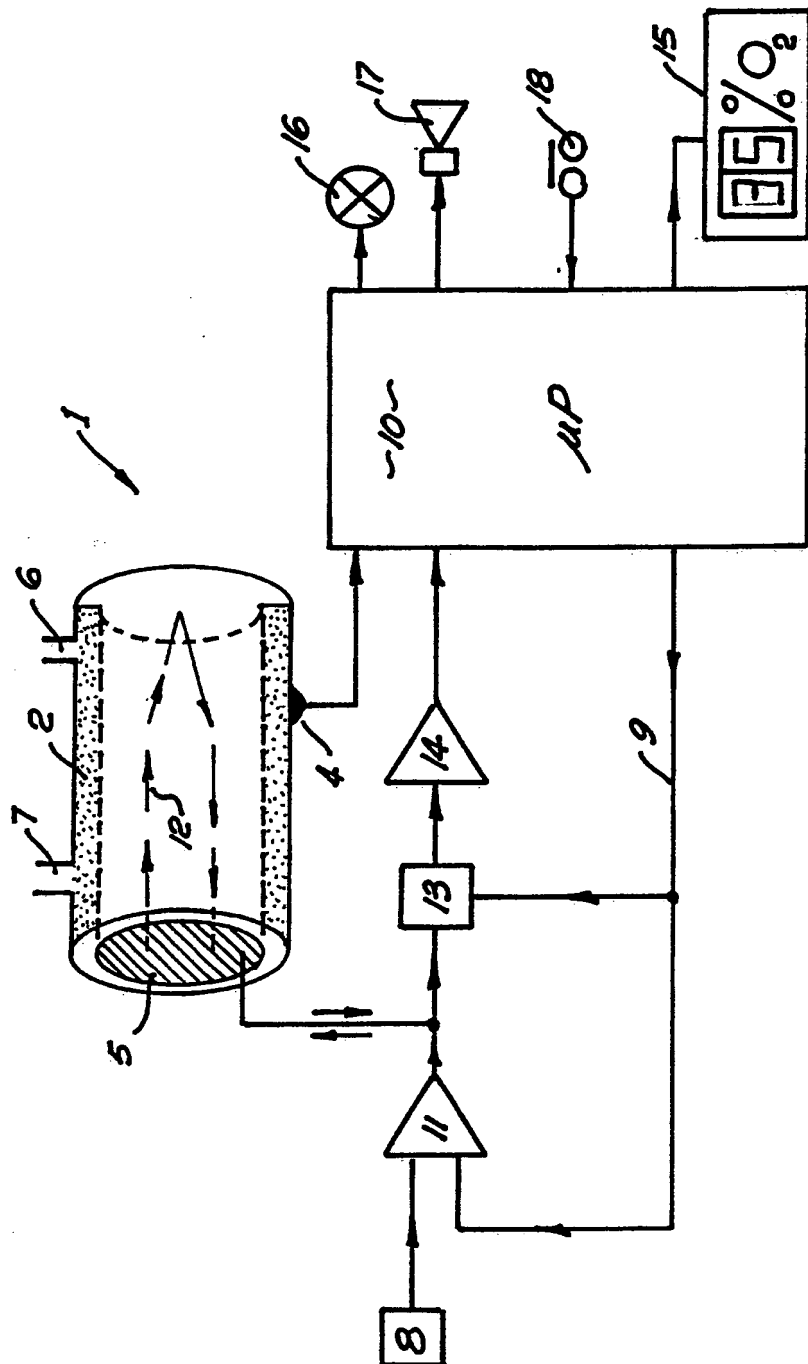


FIG. 1

- 2 / 2 -

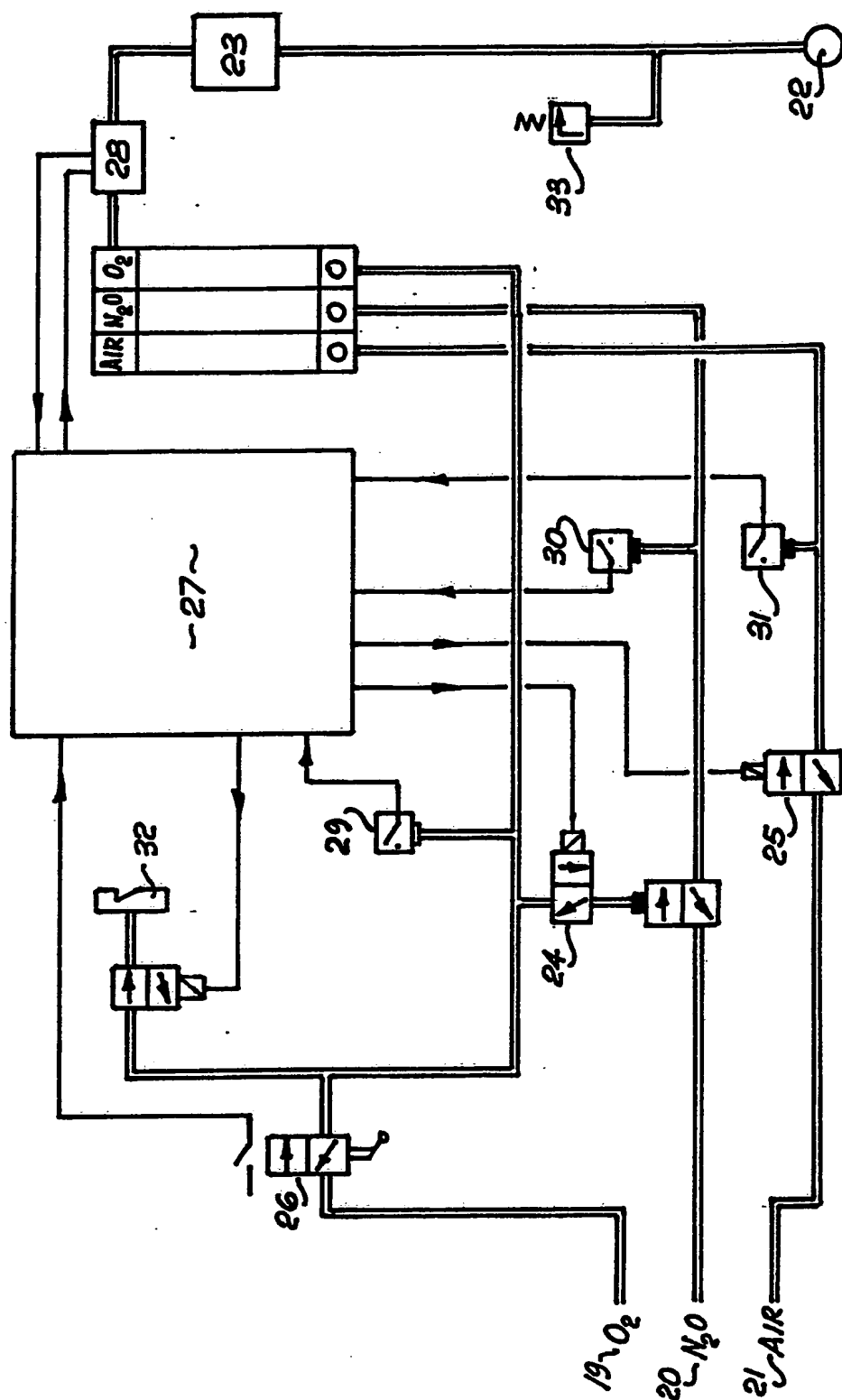
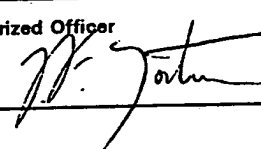


FIG. 2

INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent classification (IPC) or to both National Classification and IPC Int. Cl. ⁸ GO1N 29/02, 29/18 // A61M 16/01		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC	GO1N 29/02, 29/18	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
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III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate of the relevant passages ¹²	Relevant to Claim No ¹³
X,P	AU,A, 67058/90 (PURITAN-BENNETT CORPORATION) 6 JUNE 1991 (06.06.91) See pages 24-26 and abstract	1-4
X	GB,A, 2087559 (NATIONAL MARITIME INSTITUTE) 26 May 1982 (26.05.82) See page 1 lines 52-100	1-4
X	GB,A, 2195767 (AGRICULTURAL & FOOD RESEARCH COUNCIL) 13 April 1988 (13.04.88) See abstract	1
X	GB,A, 2210977 (GENERAL ELECTRIC CO PLC) 21 June 1989 (21.06.89) See abstract	1
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IV. CERTIFICATION		
Date of the Actual Completion of the International Search 25 November 1991		Date of Mailing of this International Search Report 11 December 91
International Searching Authority AUSTRALIAN PATENT OFFICE		Signature of Authorized Officer P.F.GOTHAM 

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

X	US,A, 4280183 (SANTI) 21 July 1981 (21.07.81) See abstract	1
X	DE,A, 3009566 (AFRISO EURO-INDEX GmbH) 17 September 1981 (17.09.81) See abstract	1
A	EP,A, 352203 (PLUESS STAUFFER A.G.) 24 January 1990 (24.01.90)	
A	GB,A, 2086044 (MICROPURE SYSTEMS INC) 6 May 1982 (06.05.82)	

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE ¹

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claim numbers ..., because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers ..., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers ..., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4a

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING ²

This International Searching Authority found multiple inventions in this international application as follows:

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2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

- ☐ The additional search fees were accompanied by applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON
INTERNATIONAL APPLICATION NO. PCT/AU 91/00367

This Annex lists the known "A" publication-level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report			Patent Family Member		
AU	67058/90	CA 2031115 US 5060514	EP 430859	JP 3223669	
EP	352203	FI 893536	FR 2634557	JP 2078915	
US	4280183	CA 1123621 DE 2917659 IT 1097696 NO 791305 FR 2448717 IT 1110717	CA 1137631 GB 2027198 NL 7903320 NO 791306 IT 1110618 JP 55107020	DE 2917651 GB 2027485 NL 7903321 US 4286565 JP 55106354	
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